15 YEARS EXPERIENCE CREATING OPEN CONTENT ENGINEERING MATERIAL

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ABSTRACT

Traditional books are created by the top–down approach. In this approach, a publisher approves or initiates a textbook. Then the publisher, using various marketing techniques, distributes the books. As opposed to this approach, open content books are created by the down to top approach. The main differences between these approaches are who makes the decision what publish and how the book is created. In a close content scheme, the decision rests with the marketing individuals and is based on economical reasoning. For open content books, the decision is not based on economical reasons per se. As a result, the books are released during production which decreases the development cycle. In the last fifteen years, three books in the area of fluid mechanics/manufacturing were created by Potto Project. What is so unique about these books is that they were created as open content books from inception. The popularity of these books is shown by the facts that they are at the top of the list in any search engine as well as having over a million downloads. Unlike close content, several publishers have been "dragged" into action and now publish these books, e.g. Amazon.com.

This "democratization" of the publishing process has several benefits which include the fast spreading of knowledge, increase of true peer review (which in turn, increases the quality and depth of book), and penetration of the books to non–traditional locations and fields. However, there are several problems in the production of open content books which include the appearance of supposably "friendly" open content agencies, lack of technical knowledge (mostly in LaTeX, html, etc.), and the need to reach a critical mass. While there are over hundreds of open content books in mathematics and low–level physics, there are less than five open content books in engineering. The difference between the creation of engineering books and others is presented (when possible). In this presentation, the benefits and pitfalls of the creation of such books is discussed.

1 Keywords

Open content, Pushka equation, Nusselt's method, Buckingham's methods, Great Depth Pressure, Practical methods, Potto Project.

NOMENCLATURE

μ Absolute Viscosity
ρ Density
τ Shear Stress
B_T Bulk Modulus
D, L Diameter, Length
g Gravity Acceleration
h Characteristic Depth
P Pressure
r Radius
t Time
U Velocity
V Volume

Dimensionless Numbers

Re Reynolds number
Eu Euler number

Subscripts

ini Initial condition
max Property at maximum
w Wall shear stress

Introduction

In the process of fifteen years of Potto Project, three textbooks and a table collection were produced: Die Casting, [1], Compressible Flow [2], the largest compressible flow tables in the world [3], and Fluid Mechanics [4]. Although the books are incomplete, several chapters of these books are very mature. While it is hard to ascertain the exact number of users, it is estimated that the number has eclipsed one million users. There are over 400 entities (web sites, universities, amazon.com) selling and/or distributing the books. In the process of writing and publishing them, several high and low points were observed. These points include the effects on the curriculum, penetration to non–traditional fields, "creation" of new material ("creating" new science), and true peer review. These, along with other difficulties in producing these books, are discussed herein.

Open content textbook, should not be confused with free textbook, is referred to a textbook where the author allows others to modify and to create derivatives. Normally, the open content textbooks are also free for the electronic version. Why the author yields some of the copyrights to others without any compensation? Newmarch ([5] and [6]) provided several reasons such integration with the users, control of the creation process, and rapid spread of the book. Perhaps Newmarch biggest satisfaction is not dealing and wrestling with the publisher's crew. Dealing with the legal issues which might be raised with enforcing the copyright, would leave any author less satisfied especially dealing with a federal court judge. In the open content there is not a strong financial incentive to plagiarize your book as in a close content. Hence, you can better deter and prevent infringing your copyright by publicizing it.

The Curriculum

Creating of a textbook forces the author to think about the curriculum (what should be included into these textbooks), the order of material presentation, the format of the presentation, the amount of mathematics used and other considerations. It has to be emphasized that these differences are not as significant for basic material like basic mathematics (such as calculus, ODE, PDE, linear algebra or physics). All the open content books surveyed which moved from a close content model to a partially open[1] content scheme also show no change such as Vadle [7], hence, they should be considered as close content books.

Fluid mechanics, compressible flow, and die casting among other subjects, have a different character. Common to all topics encountered in this experiment is the realization that there is a difference between what should be the ideal curriculum and the "preferred" curriculum. The ideal curriculum is the curriculum that is optimized for a given set of students and the university. Each university has a different ideal curriculum which might be further changed according to the students' character in that year or class. For example, Embry–Riddle Aeronautical University, which focuses on aeronautics and not general engineering knowledge or research, should teach a different curriculum of compressible flow as compared to a main stream university.

The "preferred" curriculum is the curriculum which instructors believe to be the best. Instructors tend to construct a syllabus based on what is in the textbook(s). The close content textbooks are written for what makes sales. Publishers believe that using the existing curriculum is the way to win the market, perhaps just with an improved explanation or more questions or some other extras. Publishers do not have an incentive to change and search for the ideal curriculum. This is a 'chicken or egg' dilemma when inquiring how to get the ideal curriculum into a close content model.

The removal of the sale incentive creates an openness to adopt new ideologies or techniques or doctrines. For the creation of Potto Project books, considerable time was spent on what should be included and on the order of presentation so that the book would be better (than standard presentation). Clearly, this desire (to make the books better) makes the presentation of the material in Potto Project different from the standard books. For example, for the book *Basics of Fluid Mechanics* [4], several months were spent on pondering the question of the right order. There is a big question whether the kinematics should be studied before Newton's laws and energy conservation. At this stage, the adopted approach is to skip the kinematics and instead, and follow counter intuition and teach Momentum conservation. This question was also in front of the close content textbook authors and about half of them adopted the same approach used in Potto project. Here, this search for the ideal curriculum hampers the progress of the writing of the book. Yet, this part is similar to the close content process.

While the previous example shows the similarity, the following example shows the difference. Consider the specific problem of the dimensional analysis format and presentation. The dimensional analysis is a subject that practically every respectable fluid mechanics class covers. Fundamentally, there are two main approaches to this subject: the first is known as Buckingham's method and the second is Nusselt's method (named after those individuals). Buckingham's method is the dominant method, if not the exclusive method which is taught in every fluid mechanics class. In fact, this author has not found even a single syllabus which teaches according to Nusselt's method. While these two methods start from the same arguments, both methods produce different results for most, if not all cases. Since the results are different, one has to consider whether these different results are equivalent somehow, and if not, which one of these techniques is better? Buckingham's technique is based on the idea that the governing equations must have the same units for all the different terms. In addition, this method is based on the idea that there are "atom" units from which all other units can be con-

[1] A better description of that book as a free book not as open content.

structed. Hence, no knowledge of the governing equations or boundary and initial conditions is necessary. Nusselt's technique approaches the problem from an opposite angle; the "atom" units are not an issue. The governing equations are "normalized" so dimensional numbers appear. This author has observed that the results produced by Nusselt's method are larger (more dimensionless groups) and yield better representations of the physics than those produced by Buckingham's method. Both methods have a large element of art in the solution process. However, the art elements are less significant in Nusselt's method.

EXAMPLE

To illustrate the difference between these methods, consider the example of a Newtonian incompressible liquid flow in a horizontal circular pipe. Communally, in Buckingham's method, it is assumed that the pressure difference is a function of several variables such

$$\Delta P = f\left(L, D, U, \mu, \rho\right) \tag{1}$$

Buckingham's technique yields three non–unique dimensionless groups such as $\frac{\Delta P}{\rho U^2}$, $\frac{L}{D}$. and $\frac{D U \rho}{\mu}$. It is well established[2] that equation (1) is missing some parameters to describe the physics of the flow. Unless the solution or its format is known, Buckingham's method will not provide any additional parameter. Clearly, the experiments based on Buckingham's methods provide useful results only in the extreme case of a smooth pipe, steady state, stationary coordinates, etc. Otherwise, the results of other experiments are meaningless. Suppose that such experiments for steady state smooth pipe were conducted and produced useful results. If additional dimensions or effects are needed, such as the pipe acceleration, Buckingham's method (in most cases) will not yield any additional dimensionless group. If the gravity is added, the whole process has to be repeated. This object oriented character is not maintained in this method.

Applying Nusselt's method requires writing the appropriate governing equations and representing the equations and boundary and initial conditions in a dimensionless form. The selection of governing and boundary conditions is significant because this section determines what the results will be. In this case, the N–S equations in a cylindrical is an appropriate selection as well as the vector form of N–S equations which is

$$\rho\left(\frac{\partial \mathbf{U}}{\partial t} + \mathbf{U}\cdot\nabla\mathbf{U}\right) = -\nabla P + \mu\nabla^2\mathbf{U} \tag{2}$$

[2]As explained in many fluid mechanics textbooks such as [4].

With the boundary and initial conditions of

$$\begin{aligned} \mathbf{U}\left(r = r_0\right) &= 0 \\ \mathbf{U}\left(z = 0\right) &= U_{ini}\, f\left(r\right) \\ \mu\,\frac{d\mathbf{U}}{dr} &= \tau_w g\left(z\right) \end{aligned} \tag{3}$$

It is assumed, at this state, that the no–slip condition prevails. The inlet velocity distribution could be written in the form presented in equation (3). It is interesting to point out that equation (3) indicates the existence of the friction factor, f, and implicitly the existence of the wall roughness factor. This information was not obtained or indicated by Buckingham's method.

At this stage, the characteristic dimensions need to be selected are a function of intuition or experience. In this case, the following is suggested: the characteristic length, D, is the diameter or radius (the total length appears via the energy equation). The characteristic velocity, U_{ini} is selected from several options[3]. The characteristic density, ρ, is the constant density. The driving force, $P_{max} - P_\infty$, can be the maximum pressure drive. In this case, P_{max} is the pressure at the entrance and P_∞ is the pressure at the exit. While a *priori* they are not known, one must be aware that conflicting boundary conditions cannot be assigned. Casting the above definition into mathematical form provides,

$$\begin{aligned} \tilde{\mathbf{r}} &= \frac{\vec{\mathbf{r}}}{D} & \tilde{\mathbf{U}} &= \frac{\vec{\mathbf{U}}}{U_{ini}} \\ \tilde{\mathbf{P}} &= \frac{\mathbf{P} - P_\infty}{P_{max} - P_\infty} & \tilde{\nabla} &= \frac{1}{D}\nabla \end{aligned} \tag{4}$$

These definitions suggest that the dimensionless time should be defined as

$$\tilde{t} = \frac{t\, U_{ini}}{D} \tag{5}$$

After using the definitions of the dimensionless parameters equation (2) becomes

$$\frac{\partial \tilde{\mathbf{U}}}{\partial \tilde{t}} + \left(\tilde{\mathbf{U}}\cdot\tilde{\nabla}\right)\tilde{\mathbf{U}} = -Eu\tilde{\nabla}\tilde{\mathbf{P}} + \frac{1}{Re}\tilde{\nabla}^2\tilde{\mathbf{U}} \tag{6}$$

[3]A discussion on the selection of the characteristic velocity is lengthy and is a minor aspect in this paper. A longer discussion will be in the Potto book.

And the boundary conditions (3) are transformed into

$$\begin{array}{l} \tilde{\mathbf{U}}\left(\tilde{r}=1\right) = 0 \\ \tilde{\mathbf{U}}\left(\tilde{z}=0\right) = f\left(\tilde{r}\right) \\ \dfrac{d\tilde{\mathbf{U}}}{d\tilde{t}}\left(\tilde{r}=0\right) = \tilde{\tau}\, g(\tilde{z}) \end{array} \tag{7}$$

Where $\tilde{\tau} = \tau_w U_{ini}/D\mu$. There are five dimensionless groups $(Re, Eu, f, g, \tilde{\tau})$ plus several dimensional parameters ($\tilde{r}$, $\tilde{z}$, $\tilde{\mathbf{U}}$, $\tilde{P}$, and $\tilde{t}$) as opposed to three parameters obtained utilizing Buckingham's methods. Furthermore, these dimensionless parameters indicate that the solution is a function of the ratios and not the actual dimensions.

END EXAMPLE

These results are not identical and not equal in any sense. The differences between these two methods are not only the number of parameters. The differences are manifested in the recognition of the parameter's effect on the solutions. Buckingham's method recognizes only the global effects or parameters such as L/D. Nusselt's method, as opposed to Buckingham's method, recognizes the local parameters such as r/D (for instance, at point $r/D = 0.5$). This recognition has a tremendous advantage. Nusselt's method also indicates that the time scales are a function of four parameters while Buckingham's method is silent about this point. The addition of a new effect adds a new dimensionless parameter which demonstrates a significant advantage of the object oriented character of Nusselt's method. Using Buckingham's method to analyze the same pipe in a vertical flow one has to start almost from scratch. In Nusselt's method, it will be done by adding just one term which leads to a new dimensionless group, Froude Number. The change in the boundary conditions does not change the dimensional analysis according to Buckingham's method. Suppose the no–slip boundary condition applicable in this case as

$$U_f - U_w = K\frac{\partial U}{\partial r} \tag{8}$$

which will provide three additional dimensionless parameters as

$$\frac{U_f}{U_{ini}} - \frac{U_w}{U_{ini}} = \frac{K}{U_{ini}D}\,\frac{\partial \tilde{U}}{\partial \tilde{r}} \tag{9}$$

In this process, only one manipulation was done for one boundary condition (one equation) indicating that Nusselt's method is intrinsically object oriented.

Besides the polymorphism nature of Nusselt's method as an object oriented technique, it has an inheritance element. This characteristic can be observed from the issue of coordinate transformation. The recognition for a need of coordinates change, which is a better way to solve the problem, is a realization of new dimensionless parameters affecting the problem. For example, geological problems such as the flow of streams in the ocean are analyzed by N–S equations in a spherical coordinates system moving with the Earth. Thus, analyzing ocean streams in a frame of Earth reference yields two or more dimensionless numbers such as Rossby and Rotating Froude numbers. The element of data abstraction is intrinsically part of the dimensional analysis but it seems to be better implemented in Nusselt's method. Whether or not the encapsulation element is exist in the Nusselt's method can be viewed as a controversial.

This different presentation appears in the Potto Project book as opposed to the close content development scheme because the difference is in the active users. In close content, the most active users are the instructors who normally focus on getting new questions and manual solutions. Their need is educational in nature. However, in open content, many of the users (at least for Potto Project books) are engineers who need to solve real problems. All the cases that this author has encountered have established governing equations. While Buckingham's method is extensively and perhaps exclusively taught in universities, this method is seldom used by the very same instructors or other researchers. This author has not experienced any case which exhibits better usefulness of Buckingham's method as compared to Nusselt's method.

Thus, the Potto Project fluid mechanics book is written with this duality. On one hand, it contains considerable material about Buckingham's method so students can use it in traditional classes. Yet, on the other hand, it describes Nusselt's method for those who have a need to solve real world problems.

The last point, related to an ideal curriculum, is the level of complexity of presentation. The presentation of the material in any textbook or class should be, to some degree, challenging. The experience accumulated in Potto Project shows that this academic complication should be very carefully administrated. For example, Shapiro, in his famous book [8], has "several Naughty Professor" questions. In one of these questions, the focus is on at obtaining the static properties from the dynamic properties (see the Naughty Professor questions in [2]). This author is not aware of any practical application to such questions. Clearly, Shapiro had very good students. However, this is questionable if it promotes a deep understating of the subject. Thus, going over more material than the Naughty Professor material is advocated in Potto Project for the curriculum. Even though, the books are written for the actual world, students will still need a solution for the Naughty Professor questions to succeed on their tests. Hence, this material is included in the Potto books.

Penetration to Non–Orthodox fields

The open content scheme provides wonderful opportunities to interact with many kinds of users. There is a wide range of users who are interested in Potto Project books. There is a saying that "every movement can be traced to some fluids calculation." Hence, every topic has some kind of fluid mechanics issue in it. These books were found and used a wide broad variety of peoples. Who are the users of Potto Project? Many users are practitioners, such as engineers from a developed country like USA, Canada, Germany, etc. There are also users who are students from poorer countries. Other users are a large group of students from developed countries who are seeking additional information.

However, the interesting part is meeting users who are non-traditional engineers which enhances the presentation of the book. There is no pattern in these groups and the description is mostly anecdotal. Most of these users find Potto Project because of its high visibility on search engines. Some of these users contact the author with questions outside of the engineering world. For example, a zoologist had a question about a bird that flies from a hot air zone to a cold air zone. Compressible flow has a significant effect on birds' wings that fly at velocities close to the speed of sound. The bird, possibly, could transit from a subsonic flow to a supersonic flow. This question stimulated the author to think about the transition from oblique shock to Prandtl-Meyer flow. Due to this discussion, the zoologist gained a better understanding of bird hearing.

Several years ago, a story about an airplane which flew twenty times the speed of sound was circulated in several newspapers. A user found that the velocity claimed by the journalist to be inconsistent with the Mach number and in his TalkBack, he put a reference to the compressible flow book [2].

Besides the incidents with zoology and newspapers, a considerable interaction with 'green' people was observed. The term 'green' people refers loosely to nonformal engineers who are interested in renewable energy. These 'green' people normally have a limited knowledge in engineering in general and fluid mechanics in particular. However, they think up many interesting inventions which require knowledge in the thermofluid field. Many of these inventors attempt to read Potto Project books. These individuals have difficulties in understanding the material but gain enough knowledge to be able to ask this author. As a result, the books are in a process of adding worded sections intended for these kinds of users.

Potto Project is experimenting with providing extra material for these non–engineers. While many of these non–engineers are just asking for help, there are others who furnished help. For example, Roy Tate, a beekeeper turned blacksmith, did many of the English corrections in the early stages. He is the inventor of Roy's method of transmission corrections.

Creation of Science

None of the open content textbooks surveyed for this paper assert creation of a new scientific development. At most, Vadle [7], while partially free but not open content, makes the assertion of inserting of a new technology of wikimedia. Chesser, however, [9] found that this technology was already in use in many books. Hence, none of the engineering textbooks show creation of new equations or new technology. Moreover, none of the open content physics or mathematical textbooks make the claim of creating new material (new equations or new understanding).

Perhaps Potto Project is unique in this sense. This open content project makes the assertion of new developments in science. This change is due to the consequence of the readership. In Potto Project, a large portion of questions and inquiries are submitted by practitioners as opposed to a pure academic audience (students and instructors). This change of readership causes development of new equations or understanding. Some individuals have suggested that the oblique shock story [10] is a prime example for such a thing. Others suggested that the "hydraulic" question (which will be discussed below) is a better illustration of developing science. This question was raised by practicing engineers in the hydraulic equipment industry who wanted to relate the pressure to the displacement.

There are situations where the "known knowledge" is barely sufficient to tackle a problem composed of a combination of two or more physical effects with a numerical scheme. In these situations, applying the known knowledge in the best scenario compromises the accuracy of the calculations. Hence, analytical analysis of the combined effects is very useful. In this experiment, this kind of creation was encountered. To make this point concrete, consider the following question which was raised by an engineer working in hydraulic power equipment industry.

It is common to discuss the hydraulic pressure created due to the gravity in a liquid depth as

$$P = \rho\, g\, h \tag{10}$$

Later, in a traditional fluid mechanics class, the Bulk Modulus, B_T is introduced as

$$B_T = \rho\, \frac{\partial P}{\partial \rho} \tag{11}$$

If the second concept of Bulk Modulus is introduced, what is the pressure at a great depth where the density is a function the pressure? Clearly, equation (10) is not applicable. The author is not aware of any article or book which combines these two concepts. In oceanography, Talley (2011) [11] and Stewart (2003) [12] suggested the concept of density potential but it is not a solution to the problem.

Normally, complex mathematics is not dealt with in the undergraduate level and instructors suggest that the solution is obtained by numerical methods. For example, the depth can be broken into several segments for each with a constant density (at starting or end point). While this method can answer some questions directly, all the practical questions result in an implicit solution. For example, what is the required depth to achieve a specific pressure? The accuracy depends on how many segments are implemented and it is quite laborious.

First, the solution based on a pseudo equation of state was developed utilizing Taylor series. However, the solution was found to be cumbersome and the engineers did not like the solution (the solution is still in the book of *Basics of Fluid Mechanics* [4]). Back to the drawing board, several approaches seem possible: one) generating dimensionless parameters to have a general solution, two) search for a simple analytical solution approximation, and three) others.

Generally, one class of problems is referred to as differential equations and it is categorized and viewed as elliptic (requires boundary conditions), parabolic (requires initial and boundary conditions), and hyperbolic (requires only initial condition) problems. However, there is another class of problems which is referred to here as the integral problems. The difference from a physical point of view is that the first class depends on selected points, lines or surfaces but not the entire field like the other class. The difference between these two classes means that in the first class (elliptic, parabolic, and hyperbolic) the conditions (relationship to neighboring points) have to be given at one degree less as compared to the entire field. As opposed to this reduction, the integral class problem depends on the entire domain or field.

The integral class of problems appears in radiative energy transmission, limited oscillation problems and compressible flow (especially with some moving shocks). The problem in this case also falls into the integral class. Undergraduate students, and probably many graduate students, have never been exposed to either the Fredholm equation or the Volterra equation (two common categories of integral equations). The pressure in a slightly compressible fluid is obtained by the solution to an integral equation and has to be explained to those who have never seen these equations before. The desire for the solution to this problem began long before this author ever pondered over this problem. It is not clear why no one attempted to solve it analytically, perhaps because it is well established that integral equations very rarely yield a simple analytical solution. Apparently, the attempts to avoid the integral solution were not that successful. Next, a numerical scheme was constructed to solve this problem. Without a sponsor, at this stage, an attempt to solve the problem using the integral equation was made.

The first step is to construct the governing equations. The pressure due to a slightly compressible fluid is

$$P = \int_0^x g\,\rho(\xi)\,d\xi \tag{12}$$

The integration variable, ξ disappears after the integration and hence, P is a function of x only. For constant density ρ and gravity, reduce equation (12) to equation (10). Using the definition of the bulk modulus, the local density can be expressed as

$$\rho(x) = \frac{m}{V - V\,\frac{\Delta P}{B_T}} \tag{13}$$

with some manipulations, equations (13) and (12) become

$$\rho(x) = \frac{m}{V\left(1 - \int_0^x \frac{g\,\rho(\xi)}{B_T}\,d\xi\right)} \tag{14}$$

Equation (14) is a simple integral equation which was solved in the book of *Basics of Fluid Mechanics* [4] and the solution is

$$\frac{\rho(x)}{\rho_0} = \sqrt{\frac{B_T}{B_T + 2\,g\,\rho_0\,x}} \tag{15}$$

This equation is known as the Pushka equation. The density can be integrated to obtain the pressure distribution. The solution was appropriate for the system where the change in the gravity acceleration is insignificant. In a geological systems, the gravity is a strong function of distance. The general solution for a geological system appears in *Basics of Fluid Mechanics* [4].

Should this material be included in a basic fluid mechanics class and if so, in what format? Is the mathematics beyond the scope of a standard engineering education proper? In (radiative) Heat Transfer, the integral equations are bypassed with a simplistic presentation. Perhaps, in this case, because of the simplicity of this particular integral equation, it can be included or be part of a regular syllabus. The solution is self–contained and no additional mathematical background is required. The approach adapted by Potto Project is to present this material with the mathematics. Clearly, this material can be used by practitioners. The choice is in the hands of the instructors whether to introduce the mathematics in their classes. Nevertheless, the final equation should be introduced. In any case, the mathematical derivations are presented for the interested students and the practicing engineers. This example illustrates the process how the interaction with the users helped in developing the Potto Project's textbooks.

True Peer Review

Close content books go through a peer review process before publishing. In this process, the textbook is reviewed by a limited number of individuals. Under an open content model, the books are published without any peer review. There is no question whether or not the book will be published. However, the review process occurs after the publishing and continues during the life of the book. In close content, the publishing occurs through an integer type publishing that has a first edition, second edition, etc. In open content, the process is continuous with versions 0.2, 0.2.1, etc. This rolling publishing cycle allows corrections to be inserted almost immediately. In Potto Project, reviewers discuss only corrections or points of their interest. This discussion is continuous. Hence, there is a continuous peer review of the book.

What is the purpose of the review of scientific or engineering books? According to Day [13], the review process is to verify that the book is scientifically correct. A Wikipedia user, EMBareo (Eric M. Braun from The University of Texas at Arlington), suggested that the review process is to verify that the book has a stamp of approval. With this in mind, and assuming that the reviewers have **only the best intentions**, is a close content scheme of three or four selected individuals a better review than crowd review? From the experience gained in this experiment, it is a mixed bag. On one hand, in an area where many people have an interest, the benefits are tremendous. On the other hand, in the area where people have less interest, the close content method is better.

For example, the development of the hydraulic equation discussed above started with the hydraulic engineers' request, or review, about the existence of such an equation. Later, the same group of engineers criticized (reviewed) the "equation of state" solution. The review continued after the development of the solution using the integral equation. This led to a discussion (or review) from a colleague who was interested in a geological system. This colleague suggested to look at a gravity variation effect. This author extended the integral equation solution to include the gravity variation effect. This process was followed by a review from an individual who was interested in distance measurement utilizing the sound wave. Due to that discussion, the equation for sound traveling in variable gravity field was developed [4].

There are several anecdotal stories which should be presented. In the early stage, a senior NASA Theoretical Aeroacoustician stated that the content was good but the English was poor. This true peer review did not follow up with an offer to help. A discussion with an engineer for measuring equipment about using sound waves to measure distances led to the question (example) of the temperature effects on this measurement. However, there was an error in the presentation. This error was pointed out by Dr. Hero who suggested improvement which was further enhanced by this author.

Of the low points, there are areas where there is very little interest, such as the introductory thermo chapter which has little review conducted. In this sense, the close content review process is better. Perhaps the solution is to obtain a critical quality work above which will attract contributors.

The Potto Project Support

Backer (2009) [14] made the assertion that the main problem facing open content is the acceptance by main stream academia. Backer's assertion only deals with the usage and not the financial support. Potto Project has over a million users and the highest visibility in any search engine. Hence, the broad usage is in itself a confidence vote for the material. The web site collegeopentextbooks.org gives the impression that Potto Project books are somehow supported or affiliated with this web site. The existence of collegeopentextbooks.org is insignificant for the use or success of Potto Project. The records show that only three users originated from http://collegeopentextbooks.org[4]. There are other organizations similar to collegeopentextbooks.org advertising Potto Project books. It is interesting to point out that no significant traffic to Potto Project originated from these organizations.

In the early part of the Potto Project (late 1990s), there were issues with the critical mass. The big problem was how to get to the top of search engines. In the first five years many actions had to be carried out to advertise. Around the halfway through in the process Potto Project reached the critical usage. This fact could be ascertained by being on the first page of search engine for terms like "gas dynamics" and "compressible flow." About five years ago, according to www.alexa.com, Potto Project took about 33.39% of the world wide web traffic for terms like "fluid mechanics pdf." At this stage, no advertising was needed and the advertisement stopped. The main problem seemed to be of financial support rather than the lack of acceptance by the establishment.

Any project like Potto Project needs economical support. Downes (2007) [15] suggested several models where open content can thrive. The Potto Project experiment demonstrates that government support is not going to be forthcoming at least until an establishment "certifies" the project. Potto Project's failure to obtain any direct financial support does not necessarily mean that there is no grant money but rather that grants are collected by somebody else: the advertisement agencies. There are projects which do get support via selling by publishing on lulu.com as per Beezer (2009) [16]. In this experiment, this route was not successful. As strange as it may sound, individuals prefer to buy Potto books at amazon.com and sites selling 'stolen' goods and not from potto.org. Luke (1989) [17] suggested ideological so-

[4]A web site of Community College Open Textbooks Collaborative that is funded by The William and Flora Hewlett Foundation.

cial constructions as the supporting point. However, in this experiment, it was found that this ideology is not relevant to writing textbooks. The only financial support is indirect support that stems from consultation services. There is an economical push towards consultation services as the main source for supporting this experiment. The downside of this kind of support is a slow-down in the progress of the books. On the other hand, the consultation work enriches the content of the book.

Conclusion

There are several reasons which make some of Potto Project books sections better than the close content textbooks. The interaction with a wide range of users who insert issues and pose questions from the real world enhance the books quality . The review process for Potto Project books is vastly more extensive as compared to close content books (when the material reached the critical quality). The nature of open content also exposes the engineering knowledge to users from areas traditionally unable to access or obtain this material. A financial support model of Potto Project has not been developed.

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